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With reference to the other Watson planets it may safely be asserted that excepting the need of further observations of Andromache for reasons stated above, all of these planets may be stricken from any observing program for decades to come, since they may readily be identified if science so demands, on the basis of the orbits and perturbations determined under the auspices of this academy.

CONGENITAL ARTERIO-VENOUS AND LYMPHATICO-VENOUS FISTULAE. UNIQUE CLINICAL AND EXPERIMENTAL OBSERVATIONS.

By William S. Halsted

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Read before the Academy, November 18, 1918

A. Advance of proximal arterial dilation conforming to shifted position of fistula.—Thanks to the assistance of highly competent secretaries I have abstracts of about 400 cases of arterio-venous fistula. These have been studied with special reference to occasional observations on the dilation of the arteries. In 52 instances proximal dilation of the arterial trunk has been noted. I am quite sure that in almost every instance in which the fistula had existed for two or more months proximal dilation of the artery would have been demonstrable if looked for.

Congenital arterio-venous fistula is rare, particularly so when unassociated with naevus. We have been able to find reports of only 3 cases without and 6 with naevus. Of the former none has been cured, unless we except a case (von Eiselsberg's) in which an attempt to cure a fistula between the popliteal artery and vein was followed by gangrene, necessitating amputation of the thigh.

The following case, unique in several particulars, is reported to record the arterial changes observed at 2 operations, the second performed six and one-half years after the first. The patient, a girl aged eleven years, was operated upon November 15, 1911, for a congenital arterio-venous fistula below the angle of the jaw on the right side. After the removal of enormously dilated veins (lantern slide) it was found that the fistula was between one of these and the external carotid artery near the bifurcation or ventricle of the common carotid. Fortunately a careful note was made of a very small anomalous, ascending branch given off from the external carotid just proximal to the fistula (lantern slide). There was great dilation of the common carotid artery and of the external carotid proximal to the fistula, whereas the internal carotid was surprisingly small (lantern slide). The vessels concerned in the fistula formation were excised, the aberrant artery happily being spared. The child was relieved by the operation of very distressing symptoms, but a few weeks later signs of a second, smaller fistula developed at a distal point just below and in front of the ear. A second operation, proposed frequently, was not acceded to until last spring, six and one-half years after the first. At this operation, performed by Dr. Mont Reid in my presence, remarkably interesting observations were made. The tiny aberrant artery had become dilated almost to the size of a goose quill, and the internal carotid which at the first operation was strikingly small, was as large as normal, or larger (lantern slide). The explanation of the sequence of events is, I think, clear. There were originally two fistulae. The chief of these being eliminated at the first operation, the second, distal to the first, functioned more and more freely in the course of the six and one-half years. The internal carotid, small at the first operation because it was central to the main fistula, became dilated after the subordinate or distal fistula became active; and the anomalous artery, also central to the main fistula, became greatly dilated consequent upon the shifting of the fistula to a distal position.

B. Enlargement of the heart in cases of arterio-venous fistula and persistent ductus arteriosus.—A particularly interesting result of our clinical and experimental studies of arterio-venous fistula is the discovery that enlargement of the heart probably occurs, after a time, as a rule in the major cases. For ten years or more we have noted the condition of the heart in our patients with arterio-venous fistula and have, I believe, quite invariably found the heart enlarged—strikingly so in several instances. Dr. Mont Reid, of our Surgical Staff, has in preparation a report upon his experimental and clinical work on arterio-venous fistula in which he will offer convincing proof of our view that the fistula in its consequences may profoundly affect the heart as well as the veins and arteries. The skiagraphs (exhibit) show the effects of a fistula made three and one-half years ago by Dr. Reid between the carotid artery and external jugular vein of a dog. The veins of the neck on both sides are dilated and the carotid artery is dilated central to the fistula. The heart after two years shows slight enlargement, and after three years, as you observe, it has become pronouncedly increased in size. If the assumption is correct that the heart dilates in consequence of arterio-venous fistula it is important that the fact should be brought to the attention not only of surgeons but also of pathologists and internists who evidently have overlooked it.

Our experimental and clinical observations on arterio-venous fistula and partial occlusion of large arteries may ultimately aid in the explanation of the sequelae of certain congenital anomalies of the heart and aorta. May we not regard the persistent ductus arteriosis as an arterio-venous fistula, the pulmonary artery and the right heart representing the venous side of the fistula? The enlargement of the left heart we might assume to be analagous to the dilation of the artery proximal to a fistula; and in the dilation of the right heart and pulmonary artery we recall the dilation of the veins. My studies on the subject of the dilation of an artery which we find occurs distal to a constricting metal band and distal to the compression exercised by a cervical rib have led me to investigate the results of the congenital coarctations of the aorta at or beyond its isthmus. I have been interested to find that in a large percentage of these cases of coarcted aorta there is dilation beyond the site of the coarctation. The generally accepted view that this dilation is to enable the aorta to better carry on the anastomotic circulation must, it seems to me, be erroneous. When we shall have ascertained the cause of the arterial dilation obtained experimentally below constricting bands and of the dilation of the artery proximal to an arterio-venous fistula we may be able to explain the dilation of the aorta beyond the congenital coarctation.

C. Plausible explanation of the presence of blood in lymph-cysts at the second and subsequent tappings.—A few years ago, assisted by Dr. Heuer, I removed from the abdomen of a woman about forty years of age a huge congenital hygroma or lymph-cyst. The diaphragm was pushed high up into the right thorax and the liver was displaced far to the right and so rotated on its vertical axis that its inferior border instead of being transverse was parallel and almost in line with the linea alba. The enucleation of the greater part of the cyst was easily accomplished, the few adhesions being disposed of by gentle, blunt dissection. Finally, when there remained only a few filamentous fibers binding the sac to the right adrenal gland[1] and the inferior vena cava we proceeded with even more deliberation and caution. The adhesions to the vein were so delicate that the gentlest manipulation with the handle of the scalpel sufficed to break them. We had an unusually free and clear exposure of the vein and were operating without embarrassment. Suddenly blood gushed from a linear defect about 3 mm. long in the vena cava. The hemorrhage was promptly controlled and the slit in the vessel sutured. Proceeding thereafter with perhaps even greater delicacy, we were again confronted with a gush of blood from the vena cava at a higher point. Here we found a slit from 1.5 to 2 cm. long in this vein. The edges of the slit were smooth, the linear defect being clearly not due to a tear or cut. The gap in the vein was closed by suture. Dr. Heuer and I satisfactorily assured ourselves that there was no defect or special thinning of the wall of the cyst at the point contraposed to the larger of the two defects in the wall of the vena cava.[2]

The slits in the wall of the vena cava were surely not artefacts. They represented, I believe, imperfectly closed embryonic communications between the vein and lymph buds or lymphatic vessels. Dr. Florence Sabin to whom we owe so much for our knowledge of the origin and development of the lymphatic system very kindly writes me in regard to this case as follows:

> Recent work on the lymphatic system serves to demonstrate that lymphatic vessels are modified veins. It has been shown that lymphatic vessels occur first in the neck as sacs, lined with endothelium and packed with blood, which lie close to the jugular veins. The abdominal lymphatics begin as a sac which lies close to that part of the inferior cava which connects the two Wolffian bodies. Baetjer showed in 1908 that in the pig this sac which is the forerunner of the retroperitoneal lymphatics communicates for a time with the inferior vena cava. These communications between the lymphatics and the abdominal veins which are transitory in the pig were then shown to be permanent in the South American monkeys

by Silvester in 1912 (lantern slides), while in 1915 Job demonstrated similar permanent connections in rodents. Thus the study of the development of the lymphatic system affords an explanation of anomalies involving connections between the lymphatic vessels and both the renal veins and the inferior vena cava.

The statement has repeatedly been made that hygromata which at the first tapping have yielded a clear fluid may be found at all subsequent tappings to contain more or less blood. Only one explanation has been offered for the presence of the blood, viz., trauma of the wall of the cyst. This explanation has always seemed to me an unsatisfactory one because the walls of these cysts are as a rule very thin and non-vascular. May it not, in view of the findings in our case, be possible that vestigia of lymphatico-venous communications are responsible for the admixture of blood which has occasionally been noted at only the second and subsequent tappings of lymph-cysts and is more frequently found at the first tapping? The negative pressure consequent upon the aspiration of fluid from the cyst might divert for the moment a little blood from the vein which had given origin to the hygroma's lymphatic bud or vessel. Thus the contents of the sac, clear at the first withdrawal, would be blood stained at the second. Thereafter, with each tapping blood would be aspirated into the sac and hence clear fluid might never again be obtained.

[1] The relation of the cyst to the right adrenal gland was remarkable. In the course of stripping the sac's final delicate attachments we exposed a flat, black surface, evidently the spread-out medulla of the adrenal, about the size of a half dollar. Parenchymatous oozing from this surface required for its arrest a few mattress sutures of fine silk.

[2] The patient recovered promptly and has enjoyed excellent health since the operation.

TABLES OF THE ZONAL SPHERICAL HARMONIC OF THE SECOND KIND $Q_1(z)$ AND $Q_1'(z)$

By A. G. Webster and Willard Fisher

Ballistic Institute, Clark University*

Communicated, January 9, 1919

In connection with certain investigations that I was asked to make with regard to submarines it seemed convenient to have tables of the zonal harmonic of the second kind. These are desirable in various problems in mathematical physics connected with ellipsoids of revolution, such as problems in magnetism. Failing to find such tables in the literature of the subject, I requested Dr. Fisher to calculate tables of the function of the first order and its derivative for an interval that will be sufficient for most practical problems. Dr. Fisher has now left the country, and the stress of other work that prevented their publication being over, I trust that they may be available for peaceful purposes.—A. G. W.

* Contribution from the Ballistic Institute, Clark University, No. 1.